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Mr. H. H. Warner, of Rochester, N. Y., offers a prize of \$200 in gold for the discovery of any comet during this year. The conditions are that the comet must be unexpected and telescopic, excepting the comet of 1812, and the first discovery must be made in the United States or Canada, and immediate notification telegraphed to Professor Lewis Swift, of Rochester.

### THE PHILOSOPHICAL SOCIETY OF WASHINGTON.

At the 191st meeting of the Philosophical Society of Washington, January 8th, the following papers were read: (1). On a Simple Method of deriving some Equations used in the Theory of the Moon and of the Planets, by Mr. W. F. Mc K. Ritter, of the Nautical Almanac office. (2). On the Orbit of Swift's Comet, by Professor Edgar Frisby, U. S. Naval Observatory.

The elements of Swift's Comet were computed by Professor Frisby from three places observed by Professor Eastman with Washington Transit Circle, on the nights of October 25th, November 7th, and November 20th. They were recorded in "SCIENCE," January 8, 1881.

From these elements it is readily inferred that it was moving very nearly towards the earth at the time of its discovery (October 10th) by Professor Swift. On November 8th it came very near the earth's orbit, its distance from it being then about 0.069, the mean distance of the earth from the sun. Its perihelion lies a little outside of the earth's orbit, and its aphelion a little outside of Jupiter's orbit. Its perturbations therefore must at some time become immense, but for a long period it will reach its aphelion at times when Jupiter is in a remote part of his orbit. The periodic time from the above elements is about 2178<sup>4</sup>, or a little less than six years. Different periodic times have heretofore been deduced for this comet. Some were deduced at 11 years, others at 5½ years, and still others  $11 \div 3 = 3\frac{2}{3}$  years. The period of 5½ years is undoubtedly correct, the slight discrepancy being due to insufficient data. At each alternate return to its perihelion it cannot be seen, since the earth is then in the opposite part of its orbit, and the sun is between the earth and the comet. It passed nearest to the earth about the 18th of November.

The logarithms of radii vectores and distances from the earth on the given dates are—

	log. r.	log. Δ.
October 25th.....	0.035328	9.221510
November 7th.....	0.029018	9.141693
November 20th.....	0.034557	9.119295

No theory about any periodic time was assumed in these calculations.

### THE ROCHESTER MICROSCOPICAL SOCIETY.

At the annual meeting of the Rochester Microscopical Society, held on the 10th instant, the following officers were elected: President, the Rev. Myron Adams; Vice-President, H. F. Atwood; Secretary, H. C. Maine; Treasurer, Dr. C. E. Rider.

This Society now numbers one hundred and nineteen active members, and is stated to be in a flourishing condition. We trust we may occasionally hear from the Society, and that the record presented in our columns may show that a real advance in microscopical studies has been accomplished.

### ELECTRIC FISH.\*

BY THE MARCHIONESS CLARA LANZA.

The science of electricity and magnetism is clearly acknowledged to be an acquisition belonging to modern times, we might say to the last century. To the ancients this great world of ideas was completely unknown, with the exception of a few individual facts which must have appeared to them in a very puzzling light, as philosophy and physics were in a wholly powerless and perplexed condition.

If we pass over the electric phenomena of our own atmosphere, thunder and lightning, the only facts concerning electricity known to the ancients were the capacity of the magnet to attract iron, the attractive power arising between two pieces of amber when rubbed together, and the peculiar effects exhibited by electric fish.

One of the most numerous and common fish found in the Mediterranean Sea is the torpedo, which is able to eject electric shocks of such force that a man's arm has often been lamed by them. The knowledge of this fact can be traced back to the farthest antiquity. These fish are so often seen on the coasts of Italy and Greece that the effects produced by them must have led to the first experiments, made, in all probability, by fishermen and people directly inhabiting the coasts of these countries; at all events, the knowledge of this fact is much older than that relating to the magnet and amber, which certainly extends to a remote pre-historic period.

The Greek designation of these words, magnet and amber, contains no etymological relations to the qualities peculiar to these bodies, which must have appeared so mysterious to the ancients. The Greek term for magnet, *Heraklea* and *Magnetis*, denotes simply a stone found in the City of Heraklea or Magnesia—while the Greek word for amber, *Electron*, relates merely to the color of the substance. In this way it is evident that both the magnet and amber were long known to the Greeks and named by them before their peculiar physical properties were ascertained.

With the torpedo it is different. The ancient Greeks called it *Marhe*, and the verb derived from this substantive signifies to stun. In the same way the Latin name, *Torpedo*, denotes something which produces numbness and lameness. In the fish markets of Marseilles and Toulon, the torpedo is called *torpille*, and thus the word torpeur, (derived from the Latin *torpor*), is used in French to denote numbness and stupefaction. The Italian fishermen call it *Tremola* on account of the characteristic trembling sensation which its touch produces. In the Arabic *patois* of the Maltese, *Haddaila* is the name applied to an electric fish.<sup>1</sup> Thus we find that everywhere the name of the torpedo is etymologically allied to its electric capacity, which makes it evident that the knowledge of its peculiarities extends to the most distant period in the construction of language.

Perhaps of no more recent date is the practical and most interesting use which the inhabitants of the Mediterranean countries made of the torpedo's electric capacity, thus undoubtedly representing the beginning of electro-therapeutics. As a certain cure for headache one or more living torpedos placed upon the affected part was strongly recommended—just as at the present time a constant galvanic current is used as the most reliable manner of curing the same complaint.

Aside from this, the numerous passages in the Greek and Roman authors which relate to the torpedo and its effects are mostly of a subordinate interest. Their language, like ours, struggles to express that numb and trembling sensation occasioned by the electricity proceeding from the fish, and which we ourselves are unable to describe and simply designate by the name of "electric

\* Translated for "SCIENCE" from the German of Prof. Franz Boll.

<sup>1</sup> John Davey, *Anatomical and Physiological Researches*. London, 1839. Vol. I.

shock." We are informed that the fish makes use of this power to defend itself against its enemies, and also as an offensive weapon towards its victims. This means of defense, however, does not only take effect in consequence of immediate contact, but likewise when the fish is quite removed from all association with any object. It is well known that the shock has been clearly felt, as if by close contact, (harpoons, etc.), by fishermen who drew towards land a net in which was found a torpedo. When a stream of water was poured from a vessel upon the fish, the men's hands were powerfully affected, just as the frightful, stunning sensation is conveyed to the unsuspecting angler through the medium of his fishing line.

It is greatly to be regretted that the most celebrated natural investigator of antiquity did not turn his attention to torpedoes. Among the writings which are attributed to Aristotle only very brief mention is made of this extraordinary creature. This is the more to be wondered at inasmuch as Aristotle speaks of the torpedo in reference to something else, and appears to have a complete knowledge of its anatomy. He, therefore, knew that it belongs to a viviparous species, a fact which, in our own time, has been disputed by Cuvier.

Aristotle having failed to give any explanation of the torpedo, it is, perhaps, not astonishing that the rest of antiquity did not enter upon the subject. Indeed, among all the writings of the ancients which treat of the torpedo, there cannot be discovered the slightest attempt to throw any light upon this wonderful phenomenon and reduce it to purely natural causes. The best and most intellectual article found among ancient writings in regard to this point is from the pen of the Greek physician, Galenus, who lived in Rome about 200 years after Christ. He compares the effects of the torpedo to the working of the magnet.<sup>2</sup>

Besides the torpedo there is another electric fish belonging to the realm of antiquity, and in exact opposition to the former, a fresh water fish. In reality, in all the rivers of Africa, especially the Nile and its neighboring streams, from mouth to source, one of the most common fish to be met with is the *Malopternus electricus*, the electric Silurus. In size and electric power this fish is almost equal to the torpedo, but in other respects it is totally unlike the wonderful salt water creature. It is exceedingly interesting to observe that in this fish the same etymological relations and the same remedial representations in regard to nervous maladies, are found as in the torpedo. Unfortunately we are not acquainted with the name applied to it by the old Egyptians, nevertheless, we know that from the invasion of 638, which laid the foundation of the Arabian language and culture to the present day, the fish has been called *raâdah* or electric fish. The Jesuit Godigno, who in the sixteenth century undertook a journey to Abyssinia, tells us that the Ethiopians made use of this fish for the purpose of "casting out devils," or in other words to cure nervous diseases.

A passage in Athenæus where the *Marhe* is represented among the Nile fish proves that the Greeks were aware that electric fish were found there. Yet, the electric Nile fish appears to have been unintentionally identified by them with the Mediterranean torpedo, as mistakes and misconceptions concerning them extend far into the past century.

Abd-Allatif, a physician of Bagdad who lived in the twelfth century, writes as follows in his history of Egypt: "Among the animals peculiar to Egypt, we should not forget the fish called *raâdah* for the simple reason that while it lives no one can touch it without experiencing an irresistible trembling sensation. This impression is accompanied by cold, numbness, a crawling feeling and lameness in the limbs, so that it is impossible for one to remain in an upright position or hold anything. This ex-

traordinary stupefaction extends through the arm, the shoulder and entire side, however superficial and light the contact with the fish may have been. A fisherman assured me that when such a fish is caught in a net, the effect produced is distinctly felt by the man, although his hand does not touch the fish, and even remains some distance from it. When dead the *raâdah* loses this power. People accustomed to bathe in water where this fish is found say that the mere breath (?) of the *raâdah* is sufficient to produce such numbness of the body that the person affected can scarcely keep from sinking."<sup>3</sup>

We see that the knowledge of Arabian physicians concerning the *Malopternus* amounts to about the same thing as that obtained by the Greek and Roman authors in regard to the torpedo, and in both cases we are unable to discover the slightest trace of any inclination to analyse the mysterious effects of the fish.

Four hundred years later than the celebrated Arabian physician, the Jesuit Godigno, journeyed on the Nile. He speaks of the electric silurus in exactly the same terms as his predecessors, and it would be useless to mention it here in any special way, if his travels did not refer for the first time to a fact, which as an unconscious example in the study of animal electricity, deserves a place in the history of science. Godigno says:

"The Ethiopians assert (I myself have never witnessed the fact) that if a living electric fish is placed upon a heap of dead fish and allowed to move among them, the fish thus brought in contact with it are seized with an inward and inexplicable trembling to such an extent that they actually appear to be alive. The cause," he continues, "may be authenticated by those who investigate the nature of things in general, and I leave it to them to decide as to what this force of motion communicated by the electric fish to the dead ones may be."

The next author upon this theme, Francesco Redi, distinguished alike as physician, natural investigator and poet, gloriously opens the path for earnest and systematic research.

The beginning of this new era in the history of electric fish can be ascertained even to the day and hour. On the 14th of March, 1666, a freshly caught torpedo was brought to Redi, and to the examination and dissection of this one specimen we owe his masterly physiological and anatomical description of the torpedo, which no anatomist can read without the utmost admiration, and which casts the collected wisdom of antiquity into complete shade.

The most important advancement attributed to Redi, is the discovery of peculiar symmetrical organs situated on each side of the torpedo's head. To-day they go by the name of "electric organs," although the discoverer called them falciform muscles or bodies, and they were known to anatomists as such for more than a century. "It seemed to me," said Redi, in relating his experiments, "as if the painful sensations caused by the torpedo had their origin in these two falciform muscles more than in any other place." Thus the first hints were given towards the correct understanding of the fish, and the inexplicable strength of its electric power pointed out together with its peculiar organs.

Redi's suppositions were soon proved to a certainty by Lorenzini, one of his pupils, who in the year 1678 published an anatomy of the torpedo. From that period until the present day, the study of electric fish has always taken the anatomy, physiology and physics of the falciform organs for its subject, and by this means has been able to obtain deeper and more extensive knowledge. Now the torpedo is no very mysterious object, but at the same time the following question remains more or less open to discussion: How is this wonderful electric organ made, and how is the creature able to produce such extraordinary effects by means of it?

<sup>2</sup> *Galenii opera ed. Kuehn.*—Vol. VIII., p. 421.

<sup>3</sup> *Relation d'Egypte, par Abd-Allatif, médecin Arabe de Bagdad. Traduction de M. Silvestre de Sacy, Paris, 1810.*

The first attempts at solution given in regard to this inquiry were of a singularly mistaken character. It has already been said that Redi designated the electric organs as falciform muscles or bodies. This unintentional comparison of the electric organs with muscles has played an important, though by no means wholesome, part in the history of electric fish.

With that broad comprehension, that massive reproduction which subordinate intellects often accord to the master's ideas, Redi's direct successor and pupil, Lorenzini, plainly indicated the electric organs as "falciform muscles," thus entirely overlooking his teacher's apt precaution on this point. And from Lorenzini every anatomist of the following century calls these organs distinctly, and unalterably muscles, although this appellation is completely voluntary, and notwithstanding the fact that the electric organs, outwardly as well as inwardly, are totally unlike muscles of any kind.

If these organs, however, *were* muscles, it was but natural that effects analogous with those produced by muscles should be ascribed to them. There followed, consequently, a purely mechanical theory respecting the action of the organs, which was best set forth by Borelli, in 1685. His opinion was that they contracted several times in quick succession, thus giving a number of violent repulsions to the object brought in contact. This, he thought, was followed by a cramp or spasm of the same nature as that experienced by a person who strikes his elbow sharply. This theory met with universal applause. The most prominent natural investigators, Linné, Réaumur and Haller agreed perfectly with Borelli, and we may say that until the year 1750 the idea was recognized everywhere as the only possible and complete explanation ever given.

From the time of Redi to Réaumur the investigators limited their experiments to the electric fish most accessible to them—the torpedo. The electric silurus of Africa is scarcely mentioned, and if spoken of at all, it is merely to mistake it for, or identify it with, the torpedo. However, during this period the third and last known electric fish was discovered—the electric eel (*gymnotus electricus*)—found in South American rivers, and possessing the greatest bodily dimensions and the most powerful electric properties of any.

The first news of the gymnotus reached Europe about the year 1672. Later, Alexander von Humboldt made the fish famous, by describing in his book of travels, its fierce struggles with horses. Humboldt tells us that the name "Arimua," given to the eel by the South American Indians, denotes a creature that deprives of motion. He also states that in former times the gymnotus was used as a cure for paralysis. We may judge of the tremendous violence of the eel's electric discharges by quoting a fact related by Humboldt.

"On one occasion the inhabitants of a certain town were obliged to turn a street in an opposite direction because the electric eels had increased to such an extent in the rivers that every year they killed quantities of mules which were accustomed to wade through the water heavily laden."

However, before more complete information concerning the gymnotus could reach Europe, the youthful study of electricity had undergone an important modification which was destined to bear direct influence upon the theory regarding electric fish. The discovery of the Leyden jar (1745), spread through the world, and attracted universal attention. Experiments were made in all parts of the country, and everyone was anxious to learn the effects of this new natural force by his own experience and sensations.

Under these circumstances, it is not surprising that Adamson, who had studied the effects of the Leyden jar in Paris, on becoming acquainted with the electric eel in Senegal (1751), compared the latter with the former, and remarked that the shocks could be communicated like electricity through an iron wire. Dutch investigators state

the same thing in regard to the gymnotus. Its electric shocks can be conducted through a chain composed of several persons, but it is maintained that only the electric conductors transmit the shock, while insulators can touch the fish without any effect being perceived.

Nevertheless, serious doubts arose concerning the correctness of this new theory, until the year 1772, when John Walsh, an Englishman, irrefragably demonstrated the electric nature of the torpedo in a series of experiments given at La Rochelle, the old Huguenot town, in the house of Marie Seignette, the discoverer of Seignette salt. He showed simultaneously that the moment the shock occurs the back and stomach of the torpedo are differently situated in regard to the electricity. Walsh considers the "falciform muscles" as mere electric machines that are put in motion at the will of the animal. Soon afterward this old term disappeared from science altogether, and the more appropriate appellation of electric organs was bestowed in its stead. A few years later, this same Walsh undertook to make a series of experiments upon the gymnotus, several living specimens having been brought to London at his request. The conformity of the shocks was perfectly demonstrated by an electric discharge; indeed, Walsh even succeeded in causing the gymnotus to emit distinct electric sparks. Contemporaneous with these experiments by Walsh, the correctness of his theory was demonstrated in another interesting manner. The eminent natural philosopher, Cavendish, sunk under water a wooden board covered on each side with tin foil, and succeeded in imitating the electric phenomena of the torpedo as demonstrated by Walsh, by simply connecting the two sides of the board with a Leyden battery. He thus showed the curved current of the water, which completely agreed with that produced by the electricity of the torpedo. Finally he demonstrated the fact that a hand thrust into the water, although not coming in contact with the fish, must yet be affected by the electric shock proceeding from it in proportion to the distance.

Investigators received a fresh impulse through the discovery of galvanic electricity and electro-magnetism. It remained to be shown, however, that the electricity produced by the fish really possessed all the distinguishing features of galvanic electricity. Alexander Volta planned numerous experiments, which, unfortunately, were never put into execution. At the instigation of the celebrated chemist, Sir Humphrey Davy, however, one of his brothers, John Davy, performed extensive experiments in Malta upon the torpedo. He observed the diversion of the multiplier, the magnetizing of a steel rod, visible sparks, decomposition of water and nitric acid, the reduction of iodine from iodide of potassium, and, in short, the complete register from a galvanic current to the production of physical effects. He also maintained, in regard to the direction of the galvanic current, as observed in the torpedo, that at the time of the shock the creature's back is positively situated the same as the stomach. It is to the efforts made by the first natural philosophers, Faraday, Schoenbein, Colladon, E. du Bois-Reymond, and others, that science owes the explanations given in regard to the two other electric fish, the gymnotus and the silurus. It has been ascertained that the current in the former flows from head to tail, while in the latter it takes an exactly opposite direction.

Anatomists were no less prompt by exploring the construction of the electric organs than natural philosophers were the physics. The most distinguished names in anatomical science consecrated themselves, so to speak, to this particular theme. An account of these investigations can be read in the works of John Hunter, Etienne Geoffroy, St. Hilaire, Pacini, and Max Schultze. The descriptions of the torpedo and silurus written by Paolo Savi and Th. Billhary are masterpieces of anatomical research. Unfortunately, we are still without a like description of the gymnotus.

In order to obtain a thorough comprehension of the electric organs and their action, it is necessary to have re-

course to a third science, experimental physiology, to unite anatomy with natural philosophy, and thus make the result of one answer for the other. Whoever wishes to acquire a clear idea of the three electric fish and their organs must moreover keep the following points always uppermost in his mind:

The electric fish already mentioned as representing three different species are by no means individual fish as may, perhaps, be supposed. On the contrary, they are in form very similar to those belonging to the same families. For instance, the electric eel resembles, to an extreme degree, the common eel, the electric silurus those of its species inhabiting our rivers and lakes, and the torpedo all others of the ray family. Ancient zoology associated the electric fish with others of its kind which possessed no electric capacity whatever.

In each of these fish the electric organ is constructed in a unique and highly interesting manner. The most simple of all is that of the torpedo. This creature possesses two electric organs, symmetrically placed, one on each side. Like all fish of the ray species it is distinguished by a flat, broad body. However, while the ray usually has a somewhat pointed head, the torpedo has a remarkably wide one. This arises from the fact that in addition to the gills on each side of the head, the falciform electric organs discovered by Redi are also situated there. They extend along the body, one directly under the skin of the back, the other beneath the skin of the stomach. The dimensions of these organs is especially worthy of attention. In a torpedo of ordinary size (35 centimetres in length) the electric organ is about 11 centimetres long, the greatest width 5 centimetres, and the height, (the skin being removed from the back and stomach), 2 centimetres. When prepared, the organ is of the consistency and not unlike a gray, semi-transparent gelatinous substance.

In the electric silurus, as in the torpedo, a symmetrically placed organ is found on each side. It lies on the skin which assumes the thickness of a tough rind. With the exception of the extremities, (the tip of the head and tail), the substance of these organs is embedded in the entire skin of the fish. In the middle line of the back and stomach the two organs come in direct contact, so that we may say the body of the silurus is placed in a tube composed of the two electric organs which unite like two gutter tiles. From the ends of this tube the head and tail of the fish alone project, as the skin covering them contains no electric substance. When in a fresh condition the material composing the organs presents very much the same appearance as that of the torpedo. The size is considerable, the weight being more than one-fourth that of the entire body.

The electric organs of the gymnotus are by far the most extensive. This creature, the largest specimen of whose species measures the length of a man and the thickness of a good-sized thigh, does not possess the same strongly-developed, muscular constitution which distinguishes our common eel. Almost the whole body from the back of the head to the end of the tail is composed of electric organs which are situated along the vertebral column in two pairs, a large one above and a small one beneath. Above these organs, and aside from the vertebral column, are the muscles (reduced to very insignificant dimensions) which move the powerful body.

This, then, is the way in which the electric organs are distributed among the three fish, without causing them to differ in any other respect from the remainder of their species. Yet we must make one limited addition to this assertion.

The electric organs are all distinguished by an extraordinary abundance of nerves. To each individual organ is attached an immense number of nerve-fibres, which complete it in some remarkable way yet to be spoken of, and which must be regarded as a constituent part of the organ itself.

It is, of course, understood that these nerve-fibres (called electric nerves) are entirely wanting in the organization of the non-electric fish, and nothing analogous with them can be found in the latter's entire construction.

But we must go a step further. It is a fixed law, governing the entire vertebrate world, that every nerve shall spring from a particular point, or rather from a certain group of cells belonging to the organs of the nerve centres (brain and spinal cord). This group is called the centre of origin of these nerves. In many cases the individual nerve-fibres have been successfully traced to the separate ganglion groups (nerve cell groups) of a like number of cells. In these cells single apophyses have been well authenticated and make it evident that the latter become nerve-fibres in course of time; or rather the nerve fibres have been carefully observed as to their position in regard to the centre of origin, and thus warrant the conclusion that they unite with the apophyses of the ganglion cells.

In the torpedo the powerful electric nerves (five on each side) unite with the centre organ between the brain and spinal column, and form their centre of origin on each side in a massive lobe first described by Alexander von Humboldt, and called the lemon lobe on account of its peculiar color. Now the name has been changed to electric lobe.

A close microscopic examination has shown that this consists entirely of ganglion cells and nerve fibres. These excited special interest for some time among anatomists, as it was discovered that their dimensions much surpassed those of all other nerve fibres and ganglion cells.

Then Bilhary disclosed the fact that in the electric silurus, the numberless nerves which support the electric organ originate from the subdivision of a single colossal nerve; also that this enormous fibre springs from an equally large ganglion cell visible to the naked eye, which lies imbedded in a substance of its own not far from the upper end of the spinal column, and forms the electric centre of origin of the fish.

The nerves which constitute the electric organ of the gymnotus are unusually great in number (200—230 on each side). They are situated along the entire length of the spinal column and at each interval between two dorsal vertebra a nerve projects. Their origin has not yet been explained in a satisfactory manner, but the most probable supposition is that they spring from certain large ganglion cells which are found along the spinal column.

The above details show us that the three electric fish possess specific electric organs and electric nerves, and that the construction and situation of the central organs differs exceedingly from that of the nerves. If a closer examination is made, it will be seen that the three electric organs harmonize perfectly with the essential parts of their structure, and that an anatomical principle binds them together.

This anatomical principle is nothing more than the construction of the electric organs out of many thousands of perfect, symmetrically arranged layers, the so-called electric strata in which the nerves terminate. Apart from these layers there is no other demonstrable formula of the electric organs except blood vessels and tissues.

In the electric organ of the torpedo which lies between the paralleled flat portions of the back and stomach, the electric layers are arranged in a corresponding manner. They are distinguished by having a rough and a smooth side. The latter is turned towards the back, the former towards the stomach. The rough side is so called from the countless nerve ramifications which spread themselves on all sides, and at last become so diminutive that they appear to melt into the electric layers composed of a pithy, albumen-like substance. It is very much to the point that these thousands of layers should be identified as a summary of electro-motory units, and that the construction of each individual layer should be investigated in order to discover, if possible, the reason for the phen-

omenon. The fact that the nerves of the layers turn towards the negative flat portions of the fish when the shock takes place, appeared to give a by no means unimportant hint, and to indicate a relation existing between the disposition of the nerves and that of the shock.

With the gymnotus all the different proportions harmonize completely with each other. The electric layers are situated vertically along the body. A rough and a smooth side are quite distinct. In the latter numberless nerves are embedded. The rough side corresponds to the tail and the smooth side to the head. The same relations exist here as in the torpedo. With the gymnotus, however, the current goes from head to tail, and when the electric shock takes place, the nerves of the strata turn towards the negative pole of the fish.

This harmony between the nerves and the electric shock leads us to suppose that an effectual and universally recognized law is in question. Yet, while the whole world was expecting a like agreement in regard to the malopterus, anatomical and physical investigations of its organs showed a considerable difference existing between them and the two first described. It is true that electric layers are there, and also situated vertically along the creature's body. The nerves too, unite in the same manner and on the same side with the layers. But a rough and a smooth side cannot be distinguished here as in the torpedo and gymnotus, for the layers are not furnished with so great a number of nerve fibres. On the contrary, one single nerve fibre is implanted in the centre and corresponds with the tail of the fish, as is the case of the gymnotus. When the shock takes place, however, this is the positive and *not* the negative pole.

So far, no one has succeeded in removing this contradiction, and it is more than questionable whether the resemblance agreed upon by Pacini between the anatomical and physical relations of the electric layers, has really the value of a natural law or not. In laying down this principle an important anatomical fact is first to be considered which later years have succeeded in ascertaining. It has been said that the electric layers in the gymnotus possess an identical microscopical structure, which formerly was only known in the torpedo and silurus. Unfortunately, the gymnotus has not been successfully examined in regard to this, therefore the question concerning the physical explanation of the electric shock has not much significance.

These are the facts which Anatomy is capable of producing in regard to the structure of the electric organs, especially in all that concerns their relations with the nervous system. No less great is the number of facts ascertained by the means of experimental physiology, which first facilitated a thorough understanding of the electric organs and their import.

Before these facts are individualized, however, it is necessary to make a few general remarks concerning the physiology of the nervous system.

All the organs contained in the body with which those springing from the centre of origin of the nervous system unite, can be divided into two classes, according to the relation they bear to the nervous system.

First class: Organs with centripetal nerves (commonly called organs of sense). These are characterized by the fact that any influence directed upon them through the nerves is conducted to the organs of the nervous system, and there produces a sensation. This perception arises from the peculiar nature of the nerve in question. If the retina of the eye is attracted by anything, a sensation of light is produced, which influences the nerves of the skin. Any excitation of the organs of hearing causes a resounding sensation upon the nerves. Indeed, it is not even necessary that the corresponding organ should be directly attached at all. The same effect is produced when the nerve of the organ is cut and any excitation made upon the end which does not unite with the central organ. If the influence is directed upon the periphery end of the divided

nerve which is attached to the organ of sense, no natural effect will be perceived.

Second class: Terminal organs with centrifugal nerves. These do not include the organs of sense, according to any general signification. The muscles, the organs of sight, and probably the glands, all belong here. These organs, differing so completely one from the other, bear the same general relations towards the nervous system. Every influence which effects the centre of origin, particularly one made at will by the animal in question, is conducted through the nerves of the final organ, and, according to the nature of the latter, produces muscular contraction. Here also it is unnecessary that the excitation should proceed directly from the centre of origin. The same effects appear when the nerve of the terminal organ is cut and any influence directed upon it. If the excitation be directed upon the end of the nerve in connection with the centre of origin, there is no result.

It is to the second class that the electric organs belong. They are under the direct influence of the nervous system just as other organs are. They are distinguished merely by their peculiar properties, and they develop under the controlling power of the nervous system just as the muscles contract and expand by the same means.

The proof of this analogy has been given in a most complete manner by Physiology, and we will repeat it here, or, rather, give the principal details.

If the centre of origin of a muscle or any group of muscles is excited in an animal, contraction takes place. A needle thrust into the electric strata of a living torpedo occasions an immediate electric discharge.

The same results are observed when the excitation is made upon the end of the nerve connected with a muscle instead of the centre of origin.

If an electric excitation is selected for this experiment it will be seen that every irritation, however superficial, made upon the nerve proceeding from the muscle is followed by an electric shock.

If the irritations follow each other in quick succession the convulsions will be reduced to an apparently invariable state of contraction which Physiology designates as tetanus. The same excitations directed upon the electric organ produce the same effects. This is called electric tetanus.

It has been observed that a short space of time ( $\frac{1}{100}$ ) elapses between the nerve excitation and the beginning of the convulsion during which the muscle remains perfectly motionless. When the nerve of the electric organ is irritated the same result occurs.

The muscles and electric organs of animals which have been poisoned by strychnine produce very interesting effects. The nature of this poison consists (as physiology expresses it), in a condition of complete reflex irritability, that is, a state in which every excitation experienced by the nerves of sense is answered by some modification of the centrifugal nerves. If, for instance, we take a rabbit or frog which is poisoned by strychnine and shake it violently or scream loudly, you will see that spasmodic muscular contraction follows each successive irritation. If an electric fish is poisoned by strychnine the same contractions are produced, followed by an electric discharge.

We must not forget to mention that the electric organs as well as the muscles are liable to fatigue, and that just as the latter lose their capacity for contraction after continuous labor, so are the former incapable of producing any effect after repeated discharges have taken place.

The immense number of concordant facts which can be proved in regard to the electric organs and muscles, has induced physiologists to assume that an especial anatomical and physiological relation exists between them, and many consider the electric organs to be muscles remodelled in some peculiar way in which the development of electricity instead of force, and the electric shock instead of contraction, had taken place by some inexplicable means. Such suppositions as these stand in direct

opposition to physiological, chemical and anatomical facts, which recognize a vast difference between these two organs.

The preference certainly is due to that mode of investigation which casts away all artificial proofs of closer relationship between the muscles and the electric organs and regards them as independent and well-authorized members. Indeed, the reasons given by those who accept an especial connection between the two are formed merely upon the identity of this relationship with the nervous system, and not upon any similarity to the actual qualities peculiar to these organs. Such grounds, however, can have no importance as regards this question and can bring the electric organs no nearer to the muscles than to the organs of sight or any other organ.

But are the electric organs really so independent and isolated in the animal organization? And to what freak of nature are we indebted for the remarkable fact that out of all the fish that exist, only three are distinguished by such powerful weapons? The theory of evolution which now rules organic natural sciences, always has a well-tried domestic remedy on hand for such questions. This theory discovers in formations like the electric organs which stand out as prominent exceptions to the conformity of animal construction, the distinct remains of a powerfully developed species belonging to an early epoch of geology, or, in other words, the solitary descendants of a once mighty family. According to this, the appearance of the electric organs in the three fish may seem much less mysterious, and the great anatomical diversities which exhibit themselves throughout these organs are, perhaps, best explained by the idea that in these fish we have before us the final issue of a powerful species, the last remains of an extinct family. That such a family did exist is proved by the discovery of a petrified torpedo in the tertiary strata of Monte Bolca in Verona.

But also in the cotemporary creation the electric organs are not so badly developed as a superficial observer might suppose. In the non-electric torpedo of the *Kajia* species, and also those which are found in the African rivers, peculiarly constructed organs have been discovered from which an electric effect cannot be produced, but which, nevertheless, are composed of strata similar to the real electric organs. These may, perhaps, be correctly termed electric organs, which are either newly constructed or else in a state of incomplete development.

The materials so far collected by anatomists and physiologists concerning this question do not admit of a marked decision. The organs present many things in common with the electric strata it is true, but beyond this further investigation seems useless.

In one other respect physiology is likewise unable to give a definite explanation. E. du Bois-Reymond was the first to ask how it happened that the electric fish was not the victim of its own power, and how it was possible that the forcible electric discharges which killed other fish completely escaped the electric fish itself.

Now we all know that the nerves and muscles of the electric fish are excited by means of an electric current, and a much stronger one is perhaps required here than would be the case with other animals, yet the electric discharges, although of such force, produce no effect whatever upon the fish. There are influences at work here, which so far we are unable to understand. We naturally suppose, however, that the great dimensions of the nerve fibres and ganglion cells, together with a vigorous nervous system, have a great deal to do with it.

In conclusion, it still remains for us to put the greatest question of all concerning the electric fish, namely: what is the origin of that powerful force which at the creature's will so suddenly appears and departs with equal rapidity, and also what is the precise mechanism of the electric organs?

It has been shown that as science advanced, the electric fish became better known and more carefully studied.

The ancients were only aware that such a thing existed; a conviction, however, that they were incapable of analysing further. Redi taught us to consider the electric organs as the apparatus which produced the effect. E. du Bois-Reymond put the electric strata in place of the electric organs, by proving that the mechanism of the latter was reduced to the combined action of countless analogous electro-motory monads, which was explained by the supposition that when the electric discharge occurred one part of the strata was positive and the other negative. By this means our question concerning the mechanism of the electric organs is partially answered. It now remains to ask what takes place when the electric discharge occurs?

Now, in order to imitate the effects produced by the malopternus, it requires the strongest electro-motor apparatus that can be found. The natural philosopher must use the most powerful batteries contained in his laboratory, if he wishes to *approach* the force which causes 2½ pounds of water, salt and albumen to come under its influence.

The muscles are no less powerful. The dorsal muscle of a frog consists of a few grammes of water, salt and albumen, and yet it is capable of lifting a kilometre. In both cases an extraordinary development is apparent, mechanical in one and electric in the other.

Hitherto, no one has succeeded in correctly establishing the facts relating to this mechanism. Nevertheless, concerning the electric eel there is an accepted theory, which explains all the phenomena in a most satisfactory manner.

This theory originated with Colladon and E. du Bois-Reymond, and states that in the electric substance, dipolar electro-motor molecules are to be found.

In a state of repose they turn towards their pole in every direction, or else in two ways opposed to each other, so that the electricity arises on all sides and disappears without. When the shock takes place, the positive pole is turned quickly towards the electric organ whence the positive current proceeds.

## OBSERVATIONS ON ICE AND ICEBERGS IN THE POLAR REGIONS.\*

BY Lieutenant F. SCHWATKA, U. S. N.

The formation of icebergs, from the terminal fronts of glaciers, has long been a disputed point among *savants*, some contending that they derive their origin from the corroding action of the water, undermining their projecting faces until the weight of the superincumbent mass, acting as a lever, overcame the cohesive power of the glacier along some line of least resistance, when the berg fell into the sea, and was wafted away by the tide-winds and currents. Others can only account for such huge mountains of ice by supposing that the glacier, slowly crawling into the sea, and plunging beneath a denser fluid, has a buoyant effort or tendency to rise, which, at last, becomes so great that it overcomes the line of least resistance, near the shore, and the berg rises into the sea, to be at the further mercy of its uncertain elements. Both theories have proved to be correct. The former generally occurs where currents, heated in more temperate climes, pour their tepid waters northward, and expend their thermal forces in contending with the vast packs, floes, and glaciers of ice, that obstruct their polar march, and whose fast corroding action has the slow glacier only a comparatively short time in its embraces before it has undermined it. The latter results where the chilled waters from the Pole have but little effect upon the glacial front; and slow as it is, it has time to crawl into the sea to give forth its mighty masses. Sometimes both

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